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DESIGN OF THE NUSC
REPLACEMENT TCP MOORING
FOR LAKE SENECA,
DRESDEN, NEW YORK

by

William N. Seelig

FPO-1-83(20)

May 1983

Ocean Engineering

CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON NAVY YARD
WASHINGTON, DC 20374

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APPROVED BY:

Shun C. Ling

SHUN LING, P.E.

DIRECTOR, ENGINEERING
ANALYSES DIVISION

OCEAN ENGINEERING AND CONSTRUCTION PROJECT OFFICE
CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D. C. 20374

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The Transducer Calibration Platform (TCP) of the Naval Underwater System Center (NUSC), Dresden, N.Y. consists of a large (33' wide, 150' long, 4' freeboard) and a small transformer float connected to a shore power cable. The two point mooring for this facility failed in 1982 after many years (Con't)

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REPRODUCED AT GOVERNMENT EXPENSE

BLOCK 19 (Con't)

of service and a temporary mooring was installed to moor the facility for approximately one year.

The new anchoring system is a four point mooring that is similar to the nearby, but larger, SMP mooring.

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DESIGN OF THE NUSC REPLACEMENT TCP MOORING
FOR LAKE SENECA, DRESDEN, NEW YORK

by

William N. Seelig

1. Introduction

The Transducer Calibration Platform (TCP) of the Naval Underwater System Center (NUSC), Dresden, N.Y. consists of a barge (33' wide, 150' long, 4' freeboard) and a small transformer float connected to a shore power cable. The two point mooring for this facility failed in 1982 after many years of service and a temporary mooring was installed to moor the facility for approximately one year.

The new anchoring system is a four point mooring that is similar to the nearby, but larger, SMP mooring. The new TCP mooring design is shown on NAVFAC (CHESDIV) Drawing Number 326161, "Transducer Calibration Platform (TCP), 4 Point Mooring Site, Plan & Details", revised 5/10/83.

to p. 10

2. Design Conditions

The design wind is taken as 85 knots, which is 10% larger than the highest winds ever recorded at Lake Seneca. The dynamic forces due to wind gusts and waves is then taken as 33% of the static forces and the dynamic and static components combined into the design force. A total design horizontal force of 35 kips is used to design each of the mooring legs. Calculations for this design load are given in Appendix A.

The water depth at the site is 535 feet and the bottom material is mud.

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3. The New Design for the TCP Mooring

NUSC requested that the new TCP mooring be a four point moor similar in design to the nearby SMP mooring. The SMP has sinkers attached to wire rope within the water column. This location of sinkers was not duplicated on the TCP moor because of possible wear and eventual loss of sinkers.

Figure 1 shows the plan view of the newly designed TCP mooring. The exact location of this facility will be determined by a NUSC installed marker buoy. This marker buoy and the mooring will be located west of the old facility, so that the worn end of the shore power cable can be removed. The new four point mooring is to be installed by a contractor and the government will moor the barge and transformer float.

Figure 2 shows the selected mooring leg design for each of the four legs (profile view). These legs consist of the following components with the specified dimension (design load = 35 kips):

Component	Characteristics
5000# Boss anchor	approx. 120 kips of holding power (see NCEL Techdata Sheet #83-08) F.S. = 3.4 against dragging
1-1/2" chain	Proof strength is approx. 131 kips & breaking strength is 183 kips; F.S. = 3.7 for proof & F.S. = 5.2 for breaking (new chain)
1-3/4" wire rope	breaking strength is approx. 224 kips; F.S. = 6.4 against breaking (new rope)
Buoy, dia=9.5',h=5'	buoy freeboard is 2.0' during light winds, 1.5' for a 37 mph wind and submerges for a 60 mph wind (see Appendix B for buoy characteristics & design)
connecting lines 1-3/4" wire rope with chain tails	F.S. = 6.4 against breaking

See Appendix B for details of the mooring buoy design and Appendix C for selection of the other major mooring components.

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A-1

CHESAPEAKE DIVISION	PROJECT: Lake Seneca
Naval Facilities Engineering Command NDW	Station:
DISCIPLINE	E S R: Contract:
Calcs made by: SEELIG date: 5/9/83	Calculations for: Mooring Plan View
Calcs ck'd by: date:	

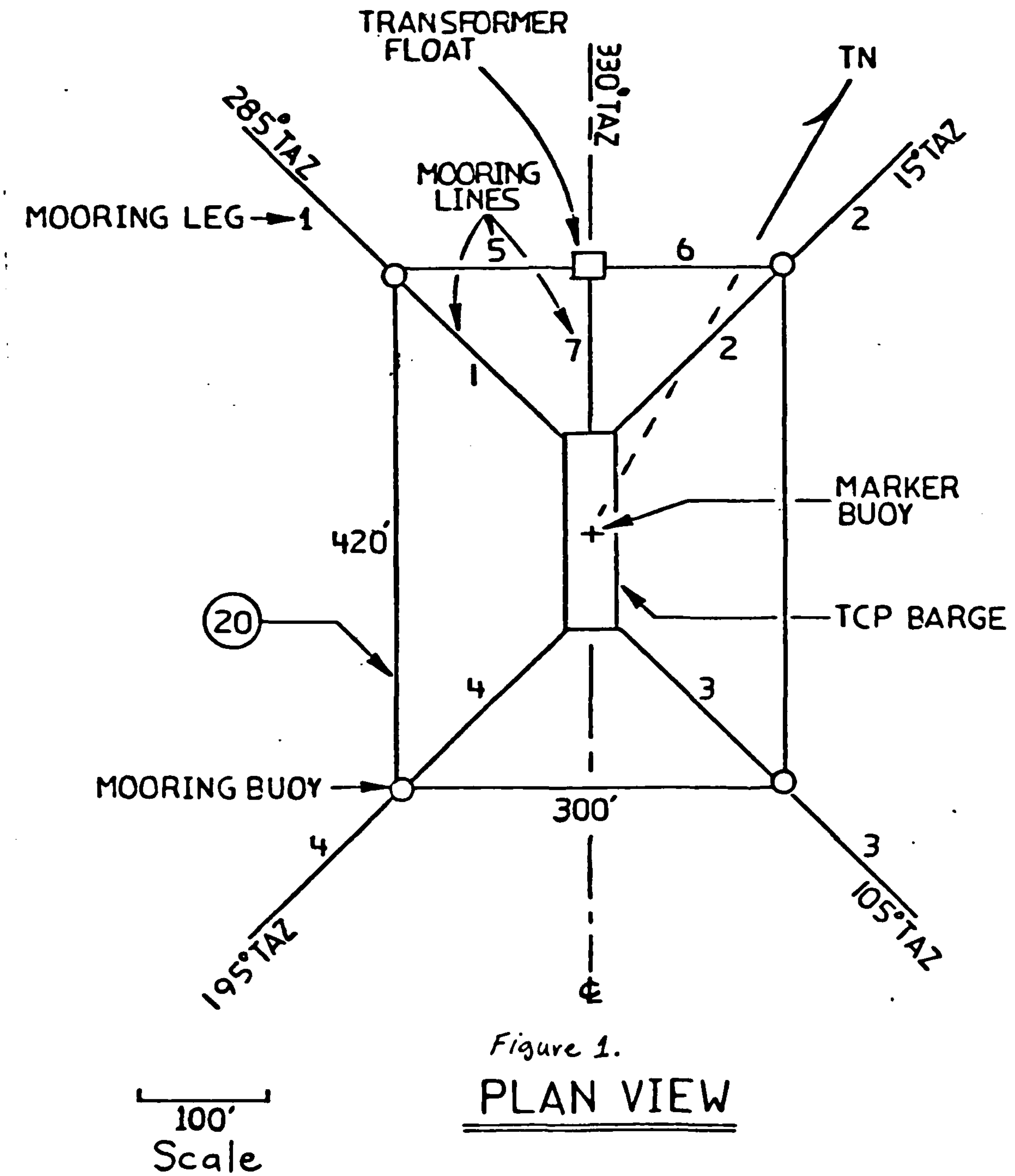


Figure 1.

PLAN VIEW

page ___ of ___

GPO 885-083

CHESAPEAKE DIVISION	PROJECT: Lake Seneca
Naval Facilities Engineering Command NDW	Station:
DISCIPLINE	E S R: Contract:
Calcs made by: Seelig date: 5/9/83	Calculations for:
Calcs ck'd by: date:	

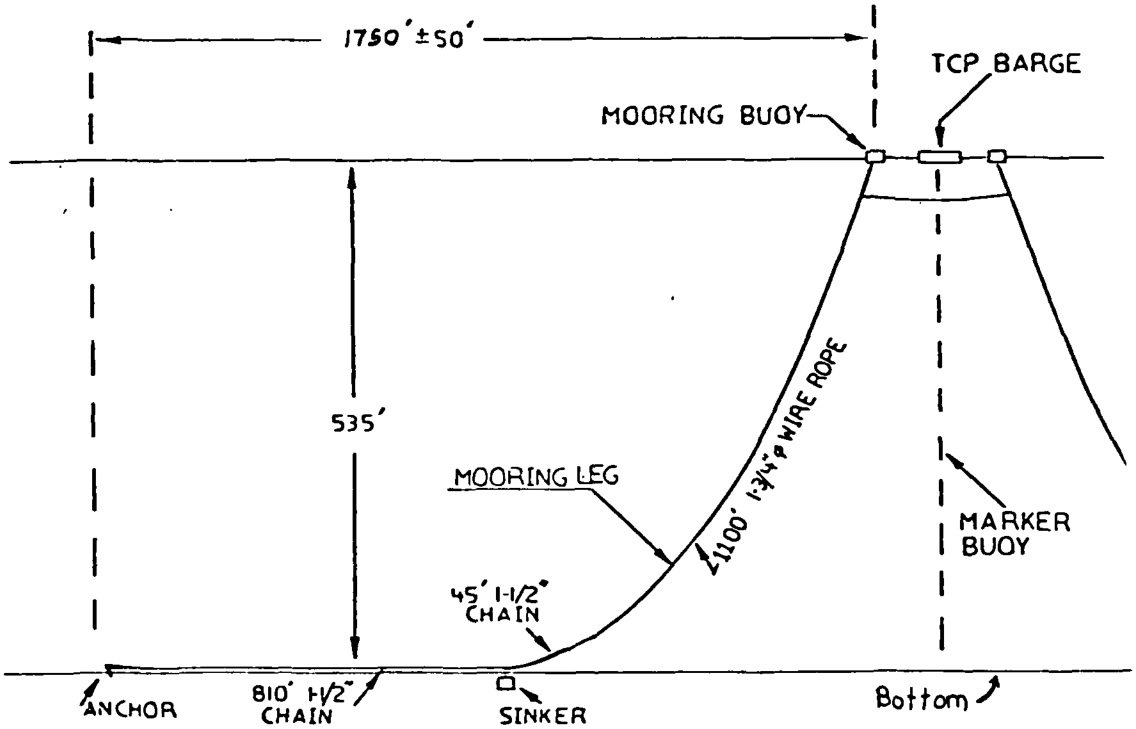


Figure 2. Profile View of the Mooring Legs

page ___ of ___

GPO 885-853

4. Load/Deflection Curve for the Mooring Legs

Figure 3 shows the predicted load/deflection curve for the mooring legs. The mooring design calls for the distance from the anchor to buoy to be a nominal 1750 $\pm$ 50', so the predicted pretension is between 2 and 5 kips. A pretension of 4 kips is expected if the anchor is placed 1800' from the buoy and then dragged until founded. In operating conditions of 30 mph winds or less the barge is predicted to move a maximum of 15' from the neutral position (30' of total motion if the wind changes direction by 180°).

Figure 4 shows the predicted length of material of the mooring leg that is on the lake bottom at various amounts of horizontal pull force at the buoy. Over 800 feet of chain is predicted to be on the bottom for forces less than 15 kips (wind speeds less than 50 mph). At the design force of 35 kips 360 feet of chain will remain on the bottom, which will provide additional holding power to the anchor and assure that the chain angle at the anchor is zero degrees.

All of the wire rope will be off the bottom at the anticipated pretension of 4 kips (Figure 5). Some of the chain is also expected to be in the water column, if the pretension reaches 5 kips.

5. The Anchor Pull Test

Anchors are to be pull tested 24 or more hours after they are set. At the specified minimum pull force of 30,000 pounds the sinker is predicted to be pulled 45' off of the lake bottom. Assuming a 190' long line is attached to the buoy to perform the pull test, the buoy is predicted to be submerged 17' and the line will have a 6° down angle (Figure 6). At 17' of submergence the buoys have a factor of safety of 2 against crushing (see Appendix D). Longer pull lines should not be used, because the possibility of crushing increases. If a longer pull line is required, then the buoy should be removed before the test is performed.

CHESAPEAKE DIVISION Naval Facilities Engineering Command NDW DISCIPLINE	PROJECT: Lake Seneca Station: E S R: Contract:
Calcs made by: SEELIG date: 4/28/83 Calcs ck'd by: date:	Calculations for: Load/Deflection Curve

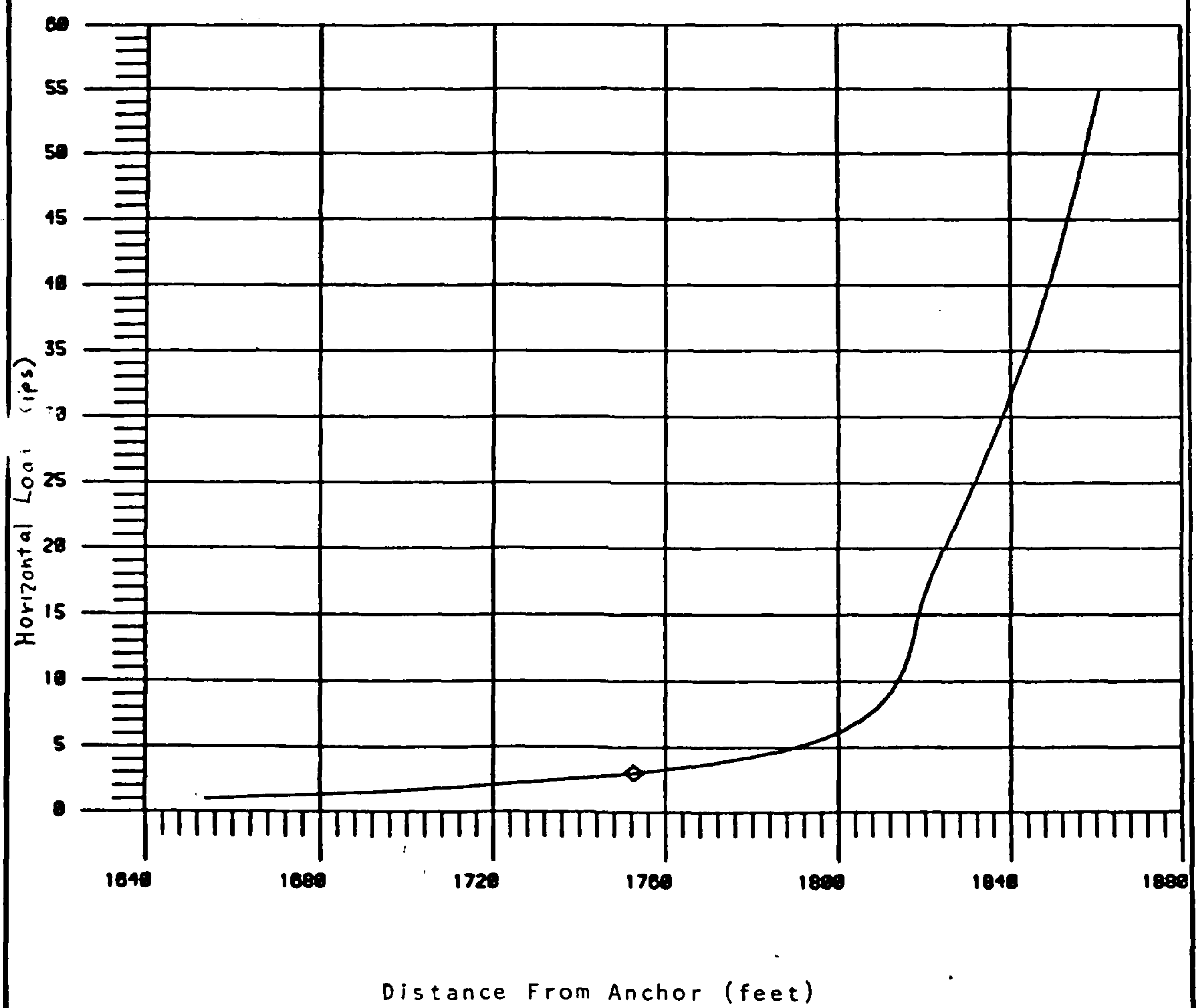


Figure 3. Load/Deflection Curve for the Mooring Legs

page ___ of ___

GPO 885-653

CHESAPEAKE DIVISION	PROJECT: Seneco
Naval Facilities Engineering Command NDW	Station:
DISCIPLINE	E S R: Contract:
Calcs made by: SEELIG date: 5/9/83	Calculations for: Length on Bottom
Calcs ck'd by: date:	

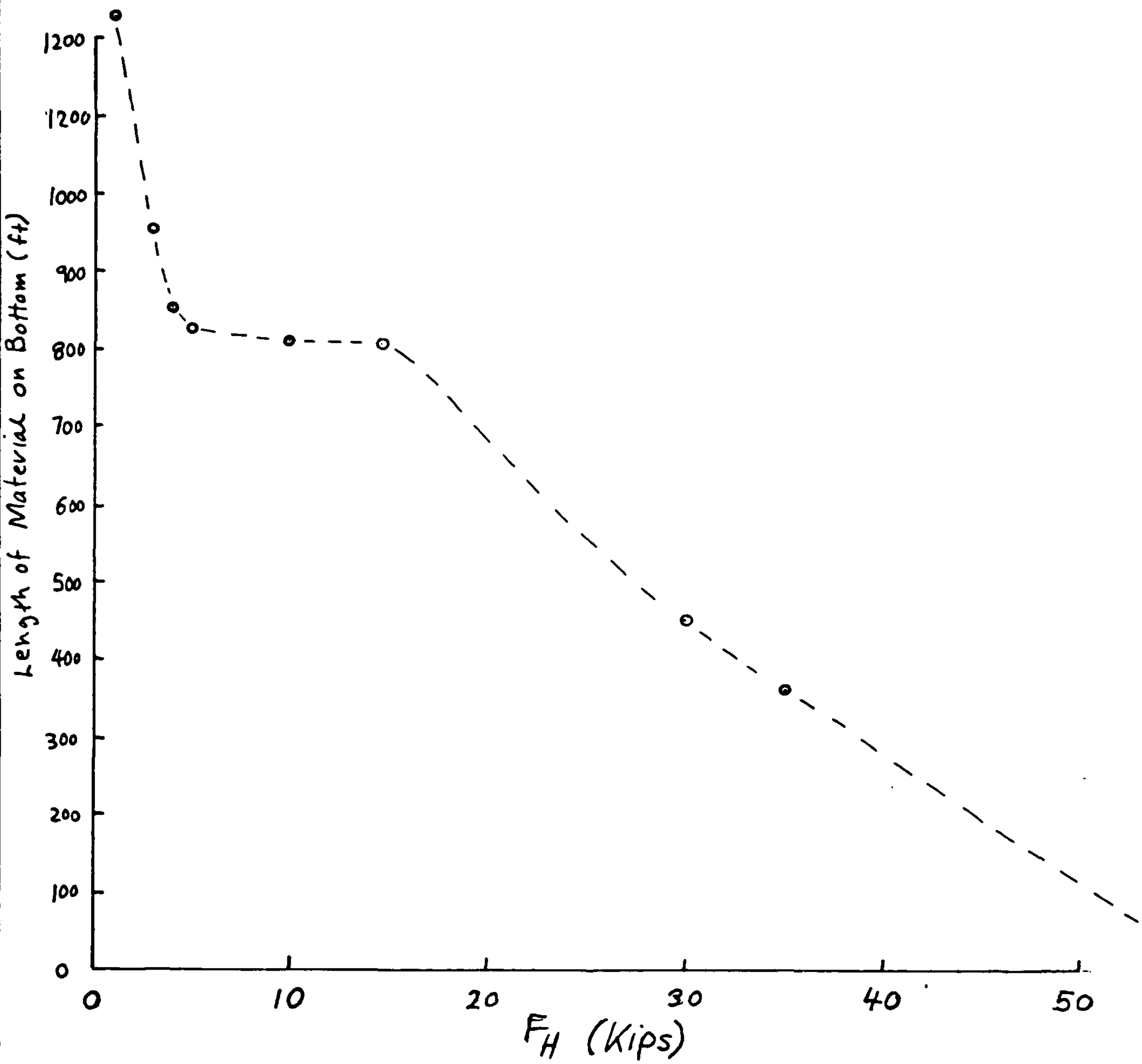


Figure 4. Predicted Length of Material on the Bottom

page ___ of ___

GPO 885-653

CHESAPEAKE DIVISION Naval Facilities Engineering Command NDW DISCIPLINE	PROJECT: Lake Seneca Station: E S R: Contract:
Calcs made by: SEELIG date: 4/28/83 Calcs ck'd by: date:	Calculations for: Chain Off Bottom

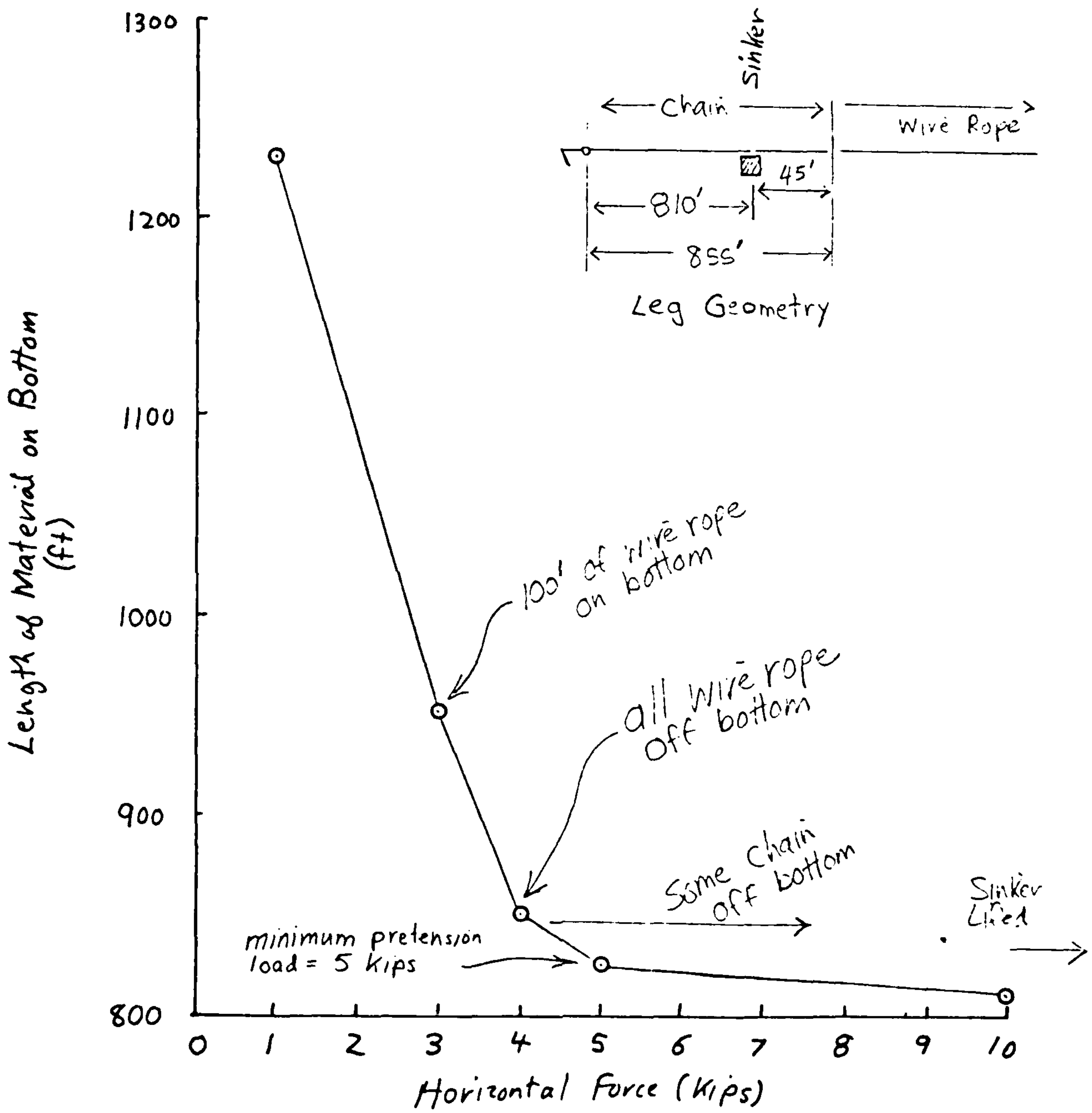


Figure 5. Predicted Length of Material on the Bottom for Light Loads

page ___ of ___

GPO 885-853

CHESAPEAKE DIVISION	PROJECT: Seneca
Naval Facilities Engineering Command NDW	Station:
DISCIPLINE	E S R: Contract:
Calcs made by: SEELIG date: 5/9/83	Calculations for: Pull Test
Calcs ck'd by: date:	

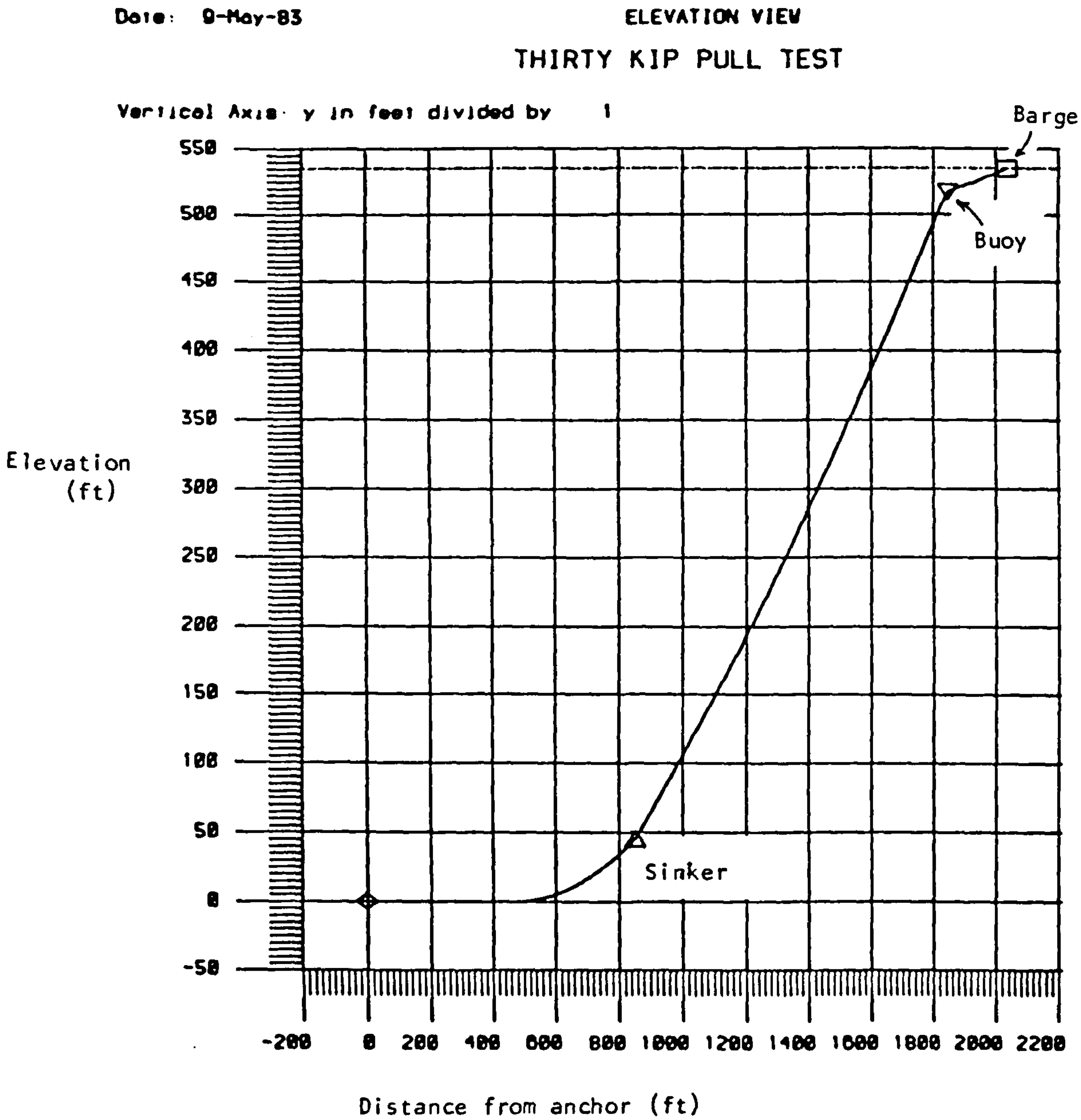


Figure 6. Predicted Conditions for the Pull Test

page ___ of ___

GPO 865-653

6. Summary

A four point mooring has been designed for the NUSC TCP facility at Lake Seneca, New York. The mooring was designed to withstand conditions 10% higher than have been observed at the site and components have a factor ~~of~~ safety of approximately four against breaking at the extreme design conditions. The mooring legs consist of drag anchors, chain, concrete sinkers, wire rope, buoys and lines for connecting the barge and transformer platform to the mooring.

Fr p. 1

The mooring has been designed to "give" or act as a shock absorber if sudden or large forces act on the TCP. For example, a front crossing the lake could produce rapid increases in the wind speed and the barge would move slightly in response to these forces. However, under normal operating conditions the leg design and specified pretension of 5 kips, the mooring will be rather "stiff" with a watch circle of less than 10' for wind speeds below 20 knots.

CHESAPEAKE DIVISION Naval Facilities Engineering Command NDW DISCIPLINE	PROJECT: Lake Seneca Station: E S R: Contract:
Calcs made by: date: Calcs ck'd by: date:	Calculations for:

APPENDIX A. DESIGN CONDITIONS

This appendix includes calculations and discussions for determining the design load of 35 kips used to design the mooring legs.

GPO 889-853

CHESAPEAKE DIVISION Naval Facilities Engineering Command NDW DISCIPLINE	PROJECT: Seneca Lake TCP Mooring Station: Seneca Lake, Dresden, NY E S R: ______ Contract: ______
Calcs made by: R.B. date: 7/12/82 Calcs ck'd by: WMS date: 18 Jul 82	Calculations for: Permanent Mooring

TCP Barge

width = 33' length = 150' draft = 7' freeboard = 4'

A_{side} = 1500 SF A_{end} = 600 SF

displacement $\Delta \cong \frac{7(150)(33)(62.4)}{2240} = 965\ LT$

Environment

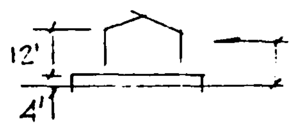
Max recorded wind velocity = 72^{kts}

Seas 6 - 8' experienced

Design wind. $72(1.10) = 82.5^{kt} = 85 kts.$

Wind Force

Reduce for lower ht of barge



center of pressure 8'

$V_{33'} = V_h \left(\frac{33}{h}\right)^{1/7}$

$85kts = V_h \left(\frac{33}{10}\right)^{1/7}$ $V_h = 85/1.19 = 71.4 kts$

Case 1 Wind formula

(1.5) shape

$F_W = 0.00256\ V^2 A$ $V = 71.4kt(1.15) = 82 mph$

$= 0.00256(82)^2(1900)$

$= 32705\ lb$

$F_{side} = 36^K$

Min waves due to small fetch.

Assume 10% inc. ∴ $F_{side} = 32705(1.1) = 35975\ lb$

GPO 889-053

CHESAPEAKE DIVISION Naval Facilities Engineering Command NDW	PROJECT: Seneca Lake TCP Mooring
DISCIPLINE	Station: Seneca Lake, Dresden, NY
	E S R: ______ Contract: ______
Calcs made by: ______ date: ______	Calculations for: ______
Calcs ck'd by: ______ date: ______	______

Case II Compare DM 26 Model EC-2 $c_f = 0.69$ $C_m = 58$
$L = 442'$ $A_{t_s} = 16700$ SF
$A_{t_e} = 3100$
draft = 7.5'

A. $\Psi = 60°$
Graph 18 $F_{ms} = 68$ lb $F_{ml} = 8$ lbs
$M_m = 40$ lb-ft

$$F_s = c_f V^2 F_{ms} \frac{A_s}{A_{t_s}} = 0.69(71.4)^2(68)\frac{(1500)}{16700} = 27214 \text{ lb}$$

$$F_l = c_f V^2 F_{ml} \frac{A_e}{A_{t_e}} = 0.69(71.4)^2(8)\frac{(600)}{3100} = 5447 \text{ lb}$$

$$M_W = C_m V^2 M_m \frac{A_s L}{A_{t_s} L_m} = 58(71.4)^2(40)\frac{(1500)(150)}{(16700)(442)} = 456,657 \text{ lb-ft}$$

Current
EC-2 use L = 410 draft = 10' displ. = 4205 LT
Graph 127 $\Psi = 60°$
$R_l = 40$ LT
yaw moment = 1800 ft tons (LT)
Reduce to 1 kt by factor 1/4

$$R_2 = R_1 \frac{\Delta_2}{\Delta_1} = 10 \frac{(965)}{4205}(2240) = 5.1^K$$

$$M_{R_2} - M_{R_1} \frac{\Delta_2 L_2}{\Delta_1 L_1} = -450 \frac{(965)(150)}{(4205)(410)} = 38 \text{ Ft-LT}$$

$$= -38(2240) = -84631 \text{ ft-lb}$$

Waves – Small fetch @ $\psi = 60°$ ∴ assume 10% incr in lateral load due waves.

GPO 888-853

CHESAPEAKE DIVISION Naval Facilities Engineering Command NDW DISCIPLINE	PROJECT: Seneca Lake TCP Mooring Station: Seneca Lake, Dresden, NY E S R: ______ Contract: ______
Calcs made by: ______ date: ______ Calcs ck'd by: ______ date: ______	Calculations for: ______

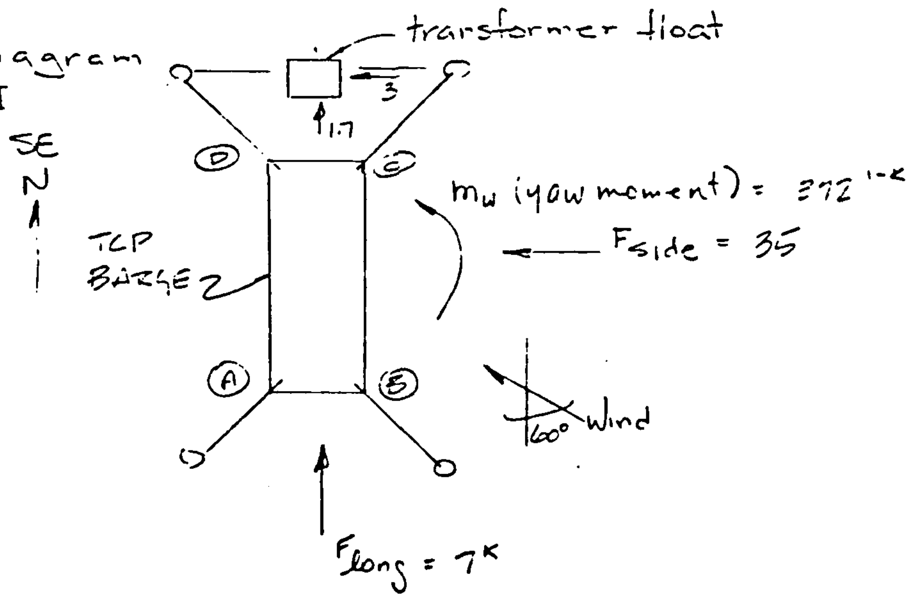
Summation of forces

Lateral Force = (Wind x 1.1 + current)
= 27214 (1.1) + 5100 = 35.0^K

Longitudinal Force = (Wind x 1.1 + current)
= 5447 (1.1) + 1000 (assumed) = 6992 lb

Yaw Moment = (Wind + current)
= 456,657 − 84,631 = 372026 ft-lb. = 372 K-ft

Force Diagram
CASE II
Wind from SE

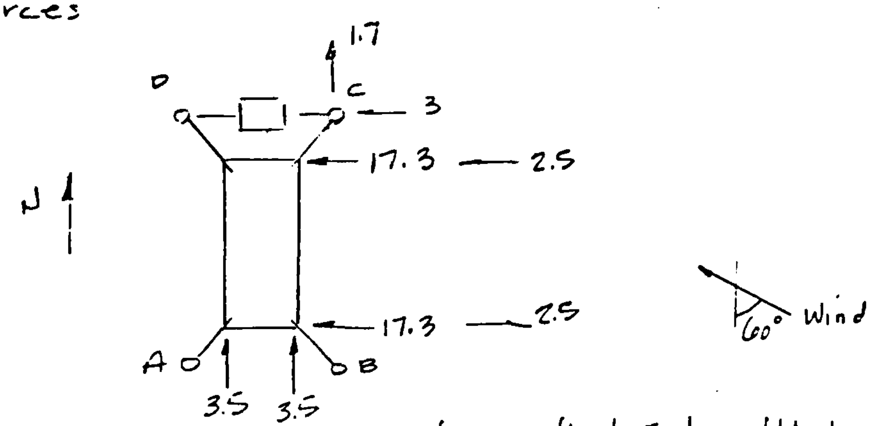


Wind force on transformer float
Area ≈ 10 x 14 = 140 Say 200 sf
$F_W = 0.00256\,V^2 A = 0.00256(82)^2(200) = 3442$ lb.
$F_{s_x} = 3.4 \sin 60° = 3^K$
$F_{\ell_x} = 3.4 \cos 60° = 1.7^K$

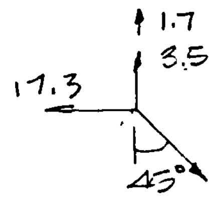
GPO 889-853

CHESAPEAKE DIVISION	PROJECT: Seneca Lake TCP Mooring
Naval Facilities Engineering Command NDW	Station: Seneca Lake, Dresden, NY
DISCIPLINE	E S R: ______ Contract: ______
Calcs made by: ______ date: ______	Calculations for: ______
Calcs ck'd by: ______ date: ______	

Distributed forces



Location B



$$F = \frac{17.3}{\sin 45^\circ} + \frac{5.2}{\cos 45^\circ} = 24.5 + 7.4$$

$$F = 32^K$$

Location C

17.3 ← 2.5 ← 3.0 ← F ↗

Unbalanced - Assume all taken by cable

$$F = \frac{22.8}{\sin 45^\circ} = 32.3^K$$

CASE III $\psi = 90^\circ$ $F_{ms} = 80$ $F_{m\ell} = 2$ $m_n = 0$

$$F_s = 0.69\,(71.4)^2 (80) \frac{1200}{16700} = 32.0^K$$

$$F_\ell = 0.69\,(71.4)^2 (2) \frac{(600)}{3100} = 1.4^K$$

GPO 885-653

CHESAPEAKE DIVISION	PROJECT: Seneca Lake TCF Mooring
Naval Facilities Engineering Command NDW	Station:
DISCIPLINE	E S R: Contract:
Calcs made by: date:	Calculations for:
Calcs ck'd by: date:	

Current $\psi = 90°$

Graph 18 $R_s = 45$ LT Yaw Moment = -2200 ft-LT

Reduce to 1 kt by factor of 1/4

$$R_c = 11.3\,(2240)\,\frac{(965)}{4205} = 5.8^K$$

$$M_m = -550\,\frac{(965)(150)}{(4205)(410)} = -46.2 \text{ ft-LT} = 103{,}438 \text{ ft-lb}$$

Force summation

Lateral force = (Wind × 1.1 + current)

$= 32(1.1) + 5.8 = 41.0^K$

Longitudinal force

$= 1.4(1.1) + 1^K = 2.5^K$

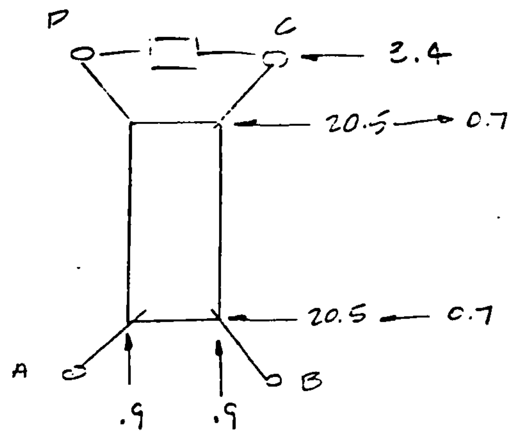
Yaw Moment $= -103.4^{\text{ ft-k}}$

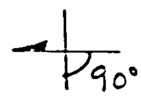
GPO 885-853

CHESAPEAKE DIVISION Naval Facilities Engineering Command NDW DISCIPLINE	PROJECT: Seneca Lake, TCP Mooring Station: E S R: Contract:
Calcs made by: date: Calcs ck'd by: date:	Calculations for:

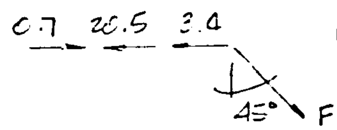
Distributed forces

Note: current - neglect lack of fetch
wave - small lack of fetch.





Location C



Unbalanced - Assume taken by cable

$F = \frac{23.2}{\sin 45^\circ} = 32.8\ k$

Comparison Wind force (Wind Vel. Eq) + Wind force (model)

$32.7^k\ (Eq) \approx 32\ ^k\ (model)\ @\ \psi = 90°$

Use Model Design Method (include current)
Critical Case single leg is Case III $\psi = 90°$
@ cable w/ transformer float
Horizontal force = 32.8 ≈ 33^k design

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GPO 885-833

CHESAPEAKE DIVISION Naval Facilities Engineering Command NDW DISCIPLINE	PROJECT: Station: E S R: Contract:
Calcs made by: date: Calcs ck'd by: date:	Calculations for:

TRY CASE IV Wind from North - max fetch

Per Graph 18 only have small amt. of longitudinal force.

Use Wind Vel. Eq. 1 & add 33% for waves

$F_W = 0.00256(22)^2(600) = 10.3^K$

$F_{W+33\%} = 10.3(1.33) = 13.7^K < \psi = 60° \text{ or } 90°$

∴ Use Horizontal Design Force = 35 kips

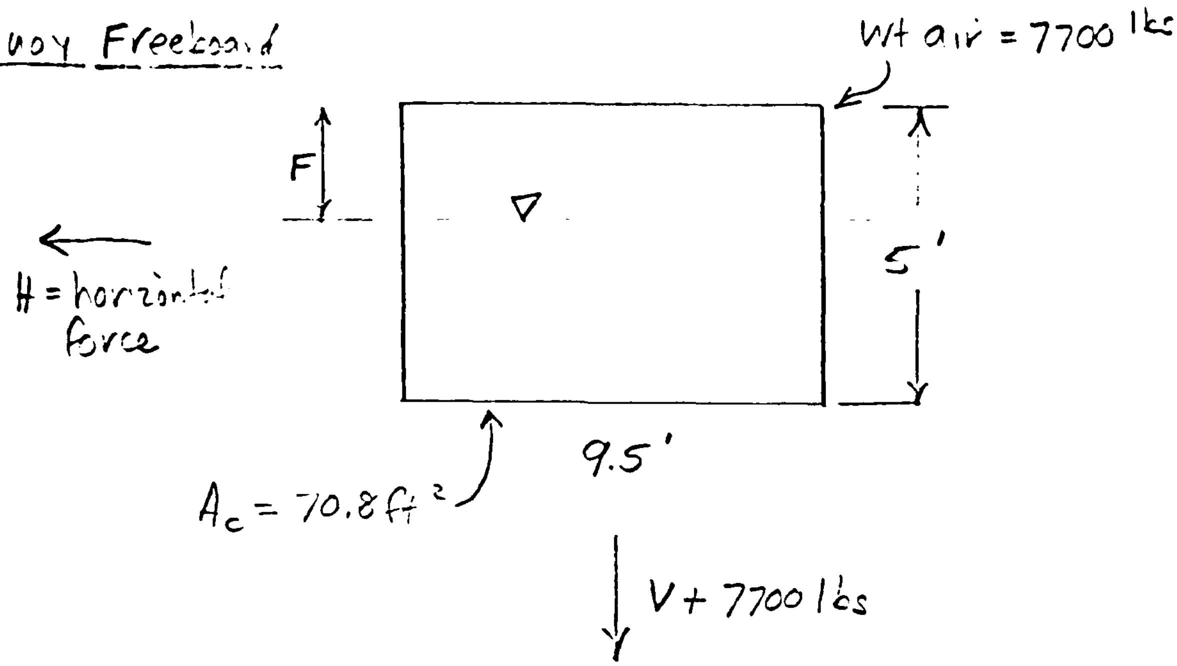
APPENDIX B. THE MOORING BUOYS

This appendix includes calculations for the buoy freeboard and gives specifications for the buoys.

Note that DM 26 (page 26-6-29) specifies that buoy freeboard of at least 18" when freely supporting the mooring material. This design uses 24", assuming a pretension of 5 kips.

CHESAPEAKE DIVISION Naval Facilities Engineering Command NDW DISCIPLINE	PROJECT: Seneca
	Station:
	E S R: Contract:
Calcs made by: Seelig date: 5/9/83	Calculations for: Buoy Freeboard
Calcs ck'd by: date:	

Buoy Freeboard



For a given vertical force, V, the buoy freeboard, F, is:

$$F = 5 - \left(\frac{W + V + 7700}{62.4 \times 70.8}\right)$$ in feet; W = wt of mooring gear.

This gives:

Condition	Buoy Freeboard (ft)
No force on buoy (H=0)	2.8'
H = 5 K (pretension)	2.0'
H = 10 K (wind = 37 mph)	1.5'
H = 18 K (wind = 60 mph)	0.0'

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MIL-B-16115D
14 June 1967

SUPERSEDING
MIL-B-16115C
28 September 1962

MILITARY SPECIFICATION

BUOYS, MOORING AND MARKER

This specification is mandatory for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers riser chain, telephone, and cylindrical mooring buoys; a peg top buoy having a cylindrical upper portion and a frustrum shaped lower portion; and tension bars for riser chain and peg top buoys.

1.2 Classification. Buoys shall be of the following types and sizes as specified (see 6.2).

Type I - Riser chain mooring buoy.

Size 6-1/2 - 6-1/2 feet diameter, 4 feet deep.
Size 7 - 7 feet diameter, 5 feet deep.
Size 9-1/2 - 9-1/2 feet diameter, 5 feet deep.
Size 10-1/2A - 10-1/2 feet diameter, 6-1/2 feet deep.
Size 10-1/2B - 10-1/2 feet diameter, 7-1/2 feet deep.
Size 12 - 12 feet diameter, 6 feet deep.

Type II - Telephone mooring buoy.

Size 14 - 14 feet diameter, 7 feet deep.
Size 15 - 15 feet diameter, 7-1/2 feet deep.
Size 16 - 16 feet diameter, 8-1/2 feet deep.
Size 17 - 17 feet diameter, 10-1/2 feet deep.

Type III - Marker buoy.

Size 3-1/2 - 3-1/2 feet diameter, spherical shape.

Type IV - Peg top mooring buoy.

Size 12 - 12 feet diameter, 9-1/2 feet deep, MK II, MOD 1.

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Type V - Cylindrical mooring buoy.

Size 5 - 5 feet 6 inches diameter, 9 feet 6 inches long, MK V.
Size 6 - 5 feet 9 inches diameter, 12 feet long, MK 2, MOD 1.
Size 8 - 8 feet diameter, 14 feet 8 inches long, MK IV.

2. APPLICABLE DOCUMENTS

2.1 The following documents of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

SPECIFICATIONS

MILITARY

MIL-T-704 - Treatment and Painting of Materiel.
MIL-S-15083 - Steel Castings.
MIL-C-18295 - Chain and Fittings for Fleet Moorings.

STANDARDS

Copy available to DTIC does not permit fully legible reproduction

MILITARY

MIL-STD-129 - Marking for Shipment and Storage.
MIL-STD-130 - Identification Marking of U.S. Military Property.
MIL-STD-271 - Nondestructive Testing Requirements for Metals.

DRAWINGS

BUREAU OF YARDS AND DOCKS (NAVAL FACILITIES ENGINEERING COMMAND)

620605 - Standard Fleet Moorings Hawse Pipe Riser Chain Type Buoy Details.
620657 - Standard Fleet Moorings Telephone Type Buoy Details Capacity 390,000 Lbs.
620659 - Standard Fleet Moorings Bar Riser Chain Type Buoy Details Capacity 160,000 Lbs.
620660 - Standard Fleet Moorings Telephone Type Buoy Details Capacity 170,000 Lbs.
620662 - Standard Marker or Mooring Buoy 3'-6" Diameter Capacity 12,000 Lbs.
620663 - Standard Fleet Moorings Chain and Fitting Details.

749872	-	Standard Fleet Moorings Tension Bars for Hawse Pipe Buoys.
749873	-	Standard Fleet Moorings Bar Riser Chain Type Buoy Details Capacity 42,000 Lbs.

BUREAU OF ORDNANCE (NAVAL ORDNANCE SYSTEMS COMMAND)

275040	-	Mooring Buoy MK IV (Cylindrical 8'0" x 14'8") General Arrangement and Details.
275043	-	Mooring Buoy Mark V (Cylindrical, 5'6" x 9'6") General Arrangement and Details.
275045	-	Peg Top Buoy Mark II General Arrangement.
275048	-	Peg Top Buoy MK II MOD 1 General Arrangement.
275083	-	Mooring Buoy MK 2 MOD 1 General Arrangement.

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

A7	-	Specification for Steel for Bridges and Buildings.
A36	-	Specification for Structural Steel.
A245	-	Specification for Flat-Rolled Carbon Steel Sheets of Structural Quality.

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.)

AMERICAN TRUCKING ASSOCIATION, INC. (ATA)

National Motor Freight Classification Rules.

(Application for copies should be addressed to the American Trucking Association, Inc., Traffic Department, 1616 P Street, N. W., Washington, D. C. 20036.)

UNIFORM CLASSIFICATION COMMITTEE (UCC)

Uniform Freight Classification Rules.

(Application for copies should be addressed to the Uniform Classification Committee, 202 Union Station, 516 West Jackson Boulevard, Chicago, Illinois 60606.)

SOUTHERN PINE INSPECTION BUREAU (SPIB)

Standard Grading Rules for Southern Pine Lumber.

(Application for copies should be addressed to the Southern Pine Inspection Bureau of the Southern Pine Association, New Orleans, Louisiana 70150.)

Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.

3. REQUIREMENTS

3.1 Preproduction sample. When specified (see 6.2), the contractor shall furnish and test a preproduction sample under the direction and supervision of the Government Inspector to determine conformance to this specification. The preproduction sample is defined as a production unit which will be identical to the units which the manufacturer will subsequently produce in fulfillment of the contract. Examination and tests shall be those specified herein. Approval of the preproduction sample shall not relieve the contractor of his obligation to supply units conforming to this specification. Any changes or deviations of production units from the preproduction sample shall be subject to the approval of the contracting officer.

3.2 Material. Material shall be as specified herein and as shown on the applicable drawings. All material shall be new and unused.

3.2.1 Structural steel. Steel plates, shapes, and bars shall conform to ASTM Designations A7 or A36. Steel sheet shall conform to ASTM Designation A245, condition and finish as appropriate. Laminated steel plate used at eyes of tension bars shall be free from defects affecting strength, when examined in accordance with 4.3.3.

3.2.2 Cast steel. Steel castings for telephone buoy swivel ring and post shall conform to MIL-C-18295 and the applicable drawings. Other castings shown on drawings shall conform to MIL-S-15083, of the class shown on the applicable drawings.

3.2.3 Wood. Lumber for rubbing and bearing strips shall be yellow pine dense structural 86 or long leaf structural 86, conforming to the SPIB Standard Grading Rules for Southern Pine Lumber. All lumber shall be creosoted as specified in 3.7.3.

3.2.4 Rubber. Rubber for fenders shall be commercial products regularly used for marine fendering, and shall be compounded for optimum resistance to salt water, weathering, oils, abrasion, compression set, and low temperature brittleness. Short lengths shall not be used.

3.3 Construction.

3.3.1 Buoys. Buoys shall be constructed as specified herein and on the applicable drawings listed in table I. The contractor shall furnish the type II buoys complete with swivel posts and swivel ring castings. Plastic rope and floats for type III buoy shall be as shown on Drawing 620662. Manholes for types I, II, and III buoys may be cut where required provided they are closed by a watertight full penetration weld around the closing plate, after all interior work has been completed and inspected.

Table I. Applicable drawings for buoys

Type	Size	Drawing No.
I	6-1/2 and 7	749873
I	9-1/2, 10-1/2A, and 10-1/2B	620659
I	12	620605
II	14, 15, and 16	620660, 620663
II	17	620657, 620663
III	3-1/2	620662
IV	12	275045, 275048
V	5	275043
V	6	275083
V	8	275040

3.3.2 Tension bars. When specified (see 6.2), tension bars constructed as specified herein and on Drawing 749872 shall be furnished with or for type I, size 12, and type IV buoys when converting from riser chain hawse pipe to the tension bar arrangement.

3.3.3 Hard facing. Unless otherwise specified (see 6.2), the surfaces of eyes in tension bars and swivel ring castings, as shown on the applicable drawings, shall be hard faced by the metal spray process. All surfaces to be faced shall be thoroughly prepared by removal of all foreign material and corrosion products and then roughened by grit blasting using an abrasive of angular steel or nonmetallic grit of a range of 25 to 40 mesh. A coating of a self-fluxing metal powder composed of chromium,

boron, nickel, and silicon shall be sprayed onto the prepared surfaces so as to produce a finished coating, after fusing, of not less than 20 mils thickness. The sprayed coating shall be fused to the base metal by uniformly heating with oxygen-acetylene torches, or in a controlled atmosphere oven, to the proper fusing temperature (approximately 1,900° Fahrenheit). Extreme care shall be exercised to prevent overheating during the fusing process in order to prevent running or sagging of the coating. The sprayed part shall be cooled slowly in accordance with recommendations of the metal spray supplier. The finished coating shall be of fine texture, uniform thickness, free of unatomized or unfused particles of metal, and shall have a hardness of 56 to 61 on the Rockwell C scale or 79 to 81.5 on the Rockwell A scale.

3.3.4 <u>Swivel posts and swivel rings</u>. The swivel posts and swivel rings shall be fabricated as shown on Drawings 620657, 620660, and 620663, and shall conform to MIL-C-18295, group 3, except that the class of casting shall be as shown on the drawings.

3.4 <u>Steel pipe and fittings</u>. Pipe shall be regular commercial seamless or welded steel pipe except where wrought iron pipe is shown on the drawings. Pipe shall be of the size, schedule, and wall thickness shown. Pipe fittings shall be standard steel and cast iron as shown.

3.5 <u>Fasteners</u>. Studs, nuts, bolts, wood screws, and capscrews shall be of the characteristics, dimensions, and quantities as shown on the drawings. Steel fasteners shall have commercial grade zinc coating.

3.6 <u>Tightness</u>. Types I, II, and III buoys shall not leak when tested by air or hydrostatic pressure in accordance with 4.3.1 or 4.3.2, the method of testing to be determined by the manufacturer. When tested hydrostatically, the buoys, and individual compartments of buoys, shall withstand an internal hydrostatic pressure of 5 pounds per square inch, maintained for a period of not less than 15 minutes, without leakage, joint failure, or abnormal bulging of plates. Types IV and V buoys shall be tested as specified on the drawings.

3.7 <u>Treatment and painting</u>.

3.7.1 <u>Metal surfaces</u>. After each buoy has passed all tests as specified, and before installation of fenders, rubbing and bearing strips, the exterior metal surfaces of all buoys, tension bars, and swivel posts, except threaded surfaces, shall be cleaned, treated, and painted in accordance with MIL-T-704, type F, except that, when specified (see 6.2), other finish paint shall be utilized. Unless otherwise specified (see 6.2), the finish color shall be lusterless black number 37038. In addition, the interior surfaces of types IV and V buoys shall be cleaned, treated, and painted in accordance with MIL-T-704, type C.

3.7.2 Threaded surfaces. The threaded surfaces of all fasteners in tapped holes, and all pipe plugs installed prior to and after testing, shall be coated with a thick mixture of red and white lead in linseed oil.

3.7.3 Wood treatment. After cutting, fitting, and drilling, all wood parts shall be pressure treated to a net retention of 20 pounds or refusal, using a creosote-coal tar solution.

3.8 Identification marking. The equipment shall be marked for identification in accordance with MIL-STD-130. Unless otherwise specified on the drawings, marking shall be 1/8 inch raised letters 1 inch high located on the buoys under railing for types I and II buoys or as shown on the applicable drawing. The legend shall include size of buoy, weight in pounds, and year of manufacture. Tension bars furnished separately shall have stenciled markings.

3.9 Workmanship.

3.9.1 Steel fabrication. Steel used in the fabrication of equipment shall be free from kinks and sharp bends. The straightening of material shall be done by methods that will not cause injury to the metal. Shearing and chipping shall be done neatly and accurately. Flame cutting, using a tip suitable for the thickness of metal, may be employed instead of shearing or sawing. Re-entrant cuts shall be made in the best possible manner. All bends of a major character shall be made with controlled means in order to insure uniformity of size and shape. Precautions shall be taken to avoid overheating, and heated metal shall be allowed to cool slowly.

3.9.2 Bolted connections. Bolt holes shall be accurately punched or drilled and shall have the burrs removed. Washers or lockwashers shall be provided in accordance with good commercial practice, and all bolts, nuts, and screws shall be tight.

3.9.3 Welding. The surface of parts to be welded shall be free from rust, scale, paint, grease, or other foreign matter. Spot, tack, or intermittent welds for strength will not be permitted. Weld penetration shall be such as to provide transference of maximum design stress through the base metal juncture. Fillet welds shall be provided when necessary to reduce stress concentration. Manual and machine welding processes and materials shall conform to applicable codes of the American Welding Society or the American Society of Mechanical Engineers, for the type of welding to be performed.

3.9.4 Machine work. Tolerances and gages for metal fits shall conform to the limitations specified herein and on the applicable drawings, and otherwise to the standards of good commercial practice.

3.9.5 Castings and forgings. Castings shall be sound and free from patching, misplaced coring, warping, or other defects which might render the casting unsound for use. Forgings shall be uniform in quality and condition, and shall be free from tears, cracks, laps, internal ruptures, imbedded scale, segregations, or other defects which would detrimentally affect the suitability for the purpose intended. Radiographic tests to detect internal defects shall be employed for castings and forgings where shown on the drawings (see 4.3.3).

3.9.6 Rubber fenders. Rubber fenders shall be uniform in appearance and workmanship, and shall be free from porous areas, bubbles, foreign matter, and other detrimental defects and irregularities.

3.9.7 Wood fabrication. Wood bearing and rubbing strips shall be neatly and accurately cut, contoured, finished, and drilled as shown, and shall fit snugly to the buoy without forcing.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own facilities or any commercial laboratory acceptable to the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

4.2 Examination. Each buoy and tension bar, including the preproduction sample, shall be examined for compliance with the requirements specified in section 3 of this specification. Examinations shall be conducted as specified in table II. Any buoy or tension bar having one or more defects shall be rejected.

Table II. List of defects

Paragraph	
3.2 through 3.2.4	Materials not as specified, and obviously damaged, used, or defective affecting serviceability and reliability.
3.3 through 3.3.4	Construction not as specified. Dimensions not as shown on referenced drawings.
3.4	Steel pipe and fittings not as specified.
3.5	Fasteners not of the characteristics, dimensions and quantities as shown on applicable drawings.

3.7 through 3.7.3	Cleaning, treating, prime coating, finish coating, film thickness, and general paint application not as specified.
3.8	Identification marking missing, incorrect, or illegible.
3.9 through 3.9.7	Workmanship is inferior and not as specified. Bolt holes not accurately punched or drilled and free from burrs; welds are sparse or incomplete; castings not sound and free from patching, misplaced coring, warping or other defects; forgings not uniform in quality and condition, and free from tears, cracks, laps, internal ruptures, imbedded scale, segregations, or other defects affecting suitability for purpose intended.

4.3 Leak tests. Tests for types IV and V buoys shall be as shown on the drawings. For types I, II, and III buoys, the preproduction sample and all production units, before painting, shall be subject to either of the following tests.

4.3.1 Pneumatic test. Each buoy, having one or more compartments, shall be tested for tightness of joints by the application of air pressure of not less than 5 pounds per square inch for a minimum period of 30 minutes. While the buoy is under pressure a soapsuds solution shall be applied externally to reveal any leaks or as an option, the pressurized buoy shall be given full immersion to detect any leaks.

4.3.2 Hydrostatic test. After completion of all welding, the buoy shall be subjected to a hydrostatic test of not less than the specified pressure (see 3.6) maintained for a period of 15 minutes. Any joint failure or leaks shall be cause for rejection. The water used for hydrostatic testing shall be made rust inhibiting by the addition of sodium dichromate at a concentration of 1/2 percent by weight. After completion of the test, each buoy shall be thoroughly drained to remove all liquids.

4.3.3 Radiographic test. Radiographic tests of parts, where shown on the drawings and required herein, shall be in accordance with MIL-STD-271; evidence of defects which would affect the strength of these parts shall be cause for rejection.

4.4 Preparation for delivery inspection. The preservation, packaging, packing and marking of the buoys and tension bars shall be inspected to verify conformance to the requirements in section 5.

5. PREPARATION FOR DELIVERY

5.1 Preservation, packaging, and packing. The following constitutes the total requirements for any level (A, B, or C), of preparation for delivery: The buoys and tension bars shall be prepared for shipment in a manner which will insure arrival at destination in satisfactory condition and which will be acceptable to the carrier at lowest rates. Packing shall comply with UCC Uniform Freight Classification Rules or ATA National Motor Freight Classification Rules.

5.2 Marking. The buoys and tension bars shall be marked in accordance with MIL-STD-129.

6. NOTES

6.1 Intended use. Types I and II buoys are used in standard fleet mooring assemblies. Type III buoys are used for marking the ends of submerged fuel transfer lines, marking centerline of tanker berth, and for small craft moorings, as appropriate for the size. Types IV and V buoys are used for mooring and flotation.

6.2 Ordering data. Procurement documents should specify the following:

(a) Title, number, and date of this specification.
(b) Type and size of buoy required (see 1.2).
(c) When preproduction sample is required (see 3.1).
(d) When tension bars shall be furnished for type I, size 12 buoy and type IV buoy (see 3.3.2).
(e) When hard surfacing shall be applied by methods other than metal spraying (see 3.3.3).
(f) When finish paint shall be other than as specified in 3.7.1.
(g) When color of finish paint shall be other than as specified (see 3.7.1).

Custodians:
Army - ME
Navy - YL

Review activities:
Navy - YD, OS

User activity:
Army - ME

Code "N"

Preparing activity:
Navy - YD

Project No. 2050-0013

*U.S. GOVERNMENT PRINTING OFFICE: 1967-301-106/236

Appendix C. Design of Other Major Components

CHESAPEAKE DIVISION Naval Facilities Engineering Command NDW DISCIPLINE		PROJECT: Lake Seneca - TCP	
		Station: Dresden, NY NUSC	
		E S R:	Contract:
Calcs made by: Seelig	date: 8/5/83	Calculations for: Summary of Major Component Selection-Wire	
Calcs ck'd by:	date:		

At the design load the tension in the wire rope is calculated to be 35 Kips. DM 26 recommends a factor of safety of 5 be used for design work. 6x37 lay is one of the strongest wire rope designs with the following characteristics:

	Wire diameter (in)	Breaking Strength (Kips)	Factor of Safety (F.S.)
	1-1/2"	165.6	4.7
	1-5/8"	192.6	5.5
	1-11/16"	208	5.9
✓	1-3/4"	224 ✓	6.4 ✓
	1-13/16"	238	6.8
	1-7/8"	254	7.26

The 1-3/4" diameter rope was selected because:

a) the F.S. is higher than recommended, which will allow extra life of the mooring

b) this is a common size to allow easy fit with hardware

c) the cost is reasonable

d) experience with this material for other moorings in the area has been satisfactory

CHESAPEAKE DIVISION Naval Facilities Engineering Command NDW	PROJECT: Seneca Lake - TCP
DISCIPLINE	Station: Dresden, NY - NUSC
	E S R: Contract:
Calcs made by: W. Seelig date: 8/4/83	Calculations for: Anchor Design
Calcs ck'd by: date:	

A 5 Kip Boss anchor is predicted to have a holding capacity of atleast 120 kips in mud, as shown on the attached figure from NCEL Techdata Sheet 83-08. The actual holding capacity will be increased by chain on the bottom.

This gives $F.S. = 120/35 = 3.4$ against dragging

Even if the anchor does drag due to some unexpected extreme event, the anchor is expected to quickly reset. In addition, the holding will actually increase as the anchor drags with half of the maximum capacity realized after the anchor drags only a distance of 5 fluke lengths.

Stabilizer bars will reduce the chance of the anchors turning and pulling out.

GPO 885-853

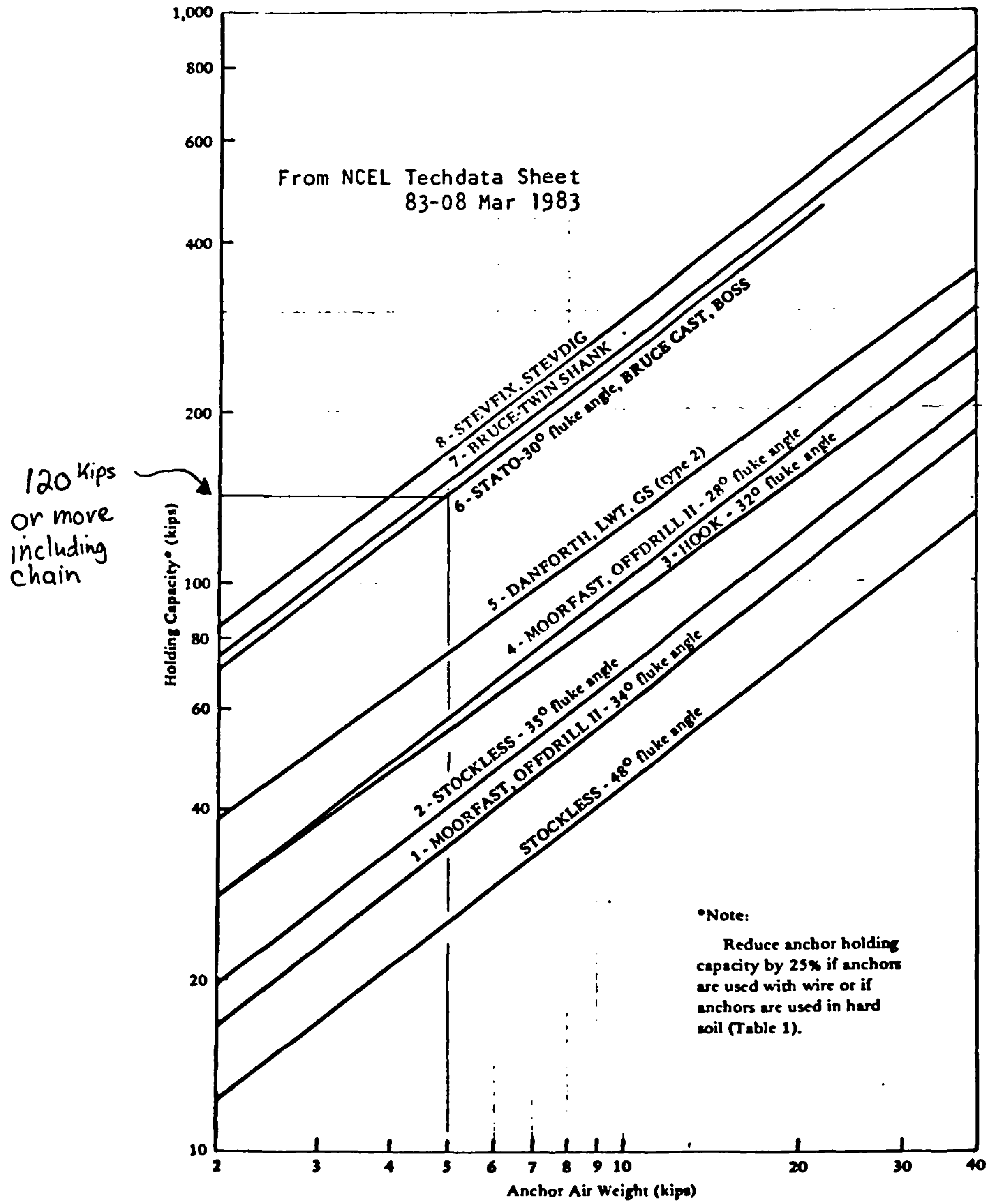


Figure 3. Holding capacity predictions for drag anchors in dense sand with chain mooring line.

CHESAPEAKE DIVISION Naval Facilities Engineering Command NDW DISCIPLINE	PROJECT: Lake Seneca - TCP Station: Dresden, NY - NUSC E S R: ______ Contract: ______
Calcs made by: W. Seelig date: 8/4/83 Calcs ck'd by: ______ date: ______	Calculations for: Chain selection

Chain should be used in the lower portion of the moorings legs to:

(1) add weight to keep the anchor angle zero
(2) add extra holding power
(3) take the wear at the mudline of being picked in and out of the mud by dynamic action in the mooring

Most of the chain will be in the mud most of the time and the water is fresh, so corrosion shouldn't be any problem.

3S Stud Link chain has:

Size (in.)	Proof Strength (Grade 2) (kips)	F.S.
1-1/4"	92.2	2.6
1-5/16"	101.5	2.9
1-3/8"	111.0	3.17
1-7/16"	120.5	3.44
1-1/2" ✓	131.0 ✓	3.74 ✓
1-9/16"	142.0k	4.06
1-5/8"	153.0k	4.37

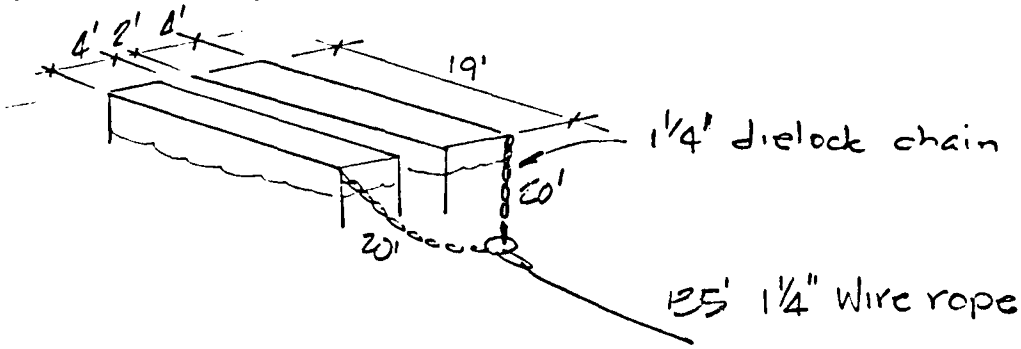
DM-26 recommends F.S. = 3 for chain proof. A 1-1/2" size chain was selected for:

1) extra safety & allowance for wear
2) additional weight to hold down the angle of the drag anchors
3) convient size

GPO 888-853

CHESAPEAKE DIVISION Naval Facilities Engineering Command NDW DISCIPLINE	PROJECT: Seneca Lake TCP Station: NUSC Dresden E S R: ______ Contract: ______
Calcs made by: R. Beckwith date: 8/5/83 Calcs ck'd by: ______ date: ______	Calculations for: Transformer mooring with chain & wire rope

Compute change of draft due to chain bridle & mooring line.



Wt. of chain –

$\frac{1415^{\#}}{20'} \times .78 = 12.26^{\#}/LF$ wet

wt of wire rope –

$2.89^{\#}/LF \times .78 = 2.25^{\#}/LF$ wet

lb/in buoyancy: $\frac{4 \times 2 \times 19 \times 62.4}{12} = 790$ lb/in draft

draft change $= \frac{2\left[40(12.26) + \frac{135}{2}(2.25)\right]}{790} = 1.6''$

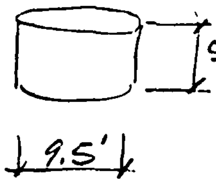
$\approx 2''$ change in draft ok

page ___ of ___

GPO 885-653

CHESAPEAKE DIVISION Naval Facilities Engineering Command NDW DISCIPLINE	PROJECT: Seneca Lake TCP Station: NUSC Dresden E S R: ____ Contract: ____
Calcs made by: R. Beckwith date: 8/5/83 Calcs ck'd by: ____ date: ____	Calculations for: Draft of NE buoy after add 90' of 1 1/4" dielock chain

Buoyancy /in of draft of buoy



wt = 1100#

$$\text{Buoyancy lb/in} = \frac{\pi (9.5)^2}{4} \frac{(62.4)}{12} = 368\ \#/\text{in.}$$

Add - 90' of 1 1/4" dielock chain
wet wt = 1415 (.78) = 1103 lb

Change of draft due addition of 1 shot

$$\frac{1103 \text{ lb}}{368 \text{ lb/in}} = 3.0'' \text{ change of draft}$$

Original freeboard = 24
Final freeboard = 24 - 3 = 21" > 18" min Ok

GPO 885-653

CHESAPEAKE DIVISION
Naval Facilities Engineering Command NDW
DISCIPLINE

Calcs made by: ______ date: ______
Calcs ck'd by: ______ date: ______

PROJECT: ______
Station: ______
E S R: ______ Contract: ______
Calculations for: ______

Appendix D. Calculated Depth at Which the Buoys will be Crushed

GPO 885-653

CHESAPEAKE DIVISION Naval Facilities Engineering Command NDW DISCIPLINE	PROJECT: TCP Mooring Station: E S R: Contract:
Calcs made by: VITALE date: 26 MAY 83 Calcs ck'd by: [illegible] date: 25 May 83	Calculations for: Buoy Crushing

THE CALCULATIONS ON THE FOLLOWING PAGES WERE DONE TO DETERMINE WHETHER THE SENECA LAKE BUOY WILL IMPLODE IF SUBMERGED TO 17 FEET DURING THE PULL TEST OF THE MOORING. STRESSES ON THE STEEL PLATES OF THE BUOY WERE CALCULATED FOR THE BOTTOM, FLAT SECTION AND THE SIDE, CURVED SECTION. THE CURVED SECTION PROVED TO BE MUCH STRONGER. THE CONTROLLING LOADS AND DEPTHS WILL THEREFORE BE BASED ON THE BOTTOM PLATE. STEEL USED IN CONSTRUCTION IS A36 WITH A YIELD STRESS OF 36 KSI.

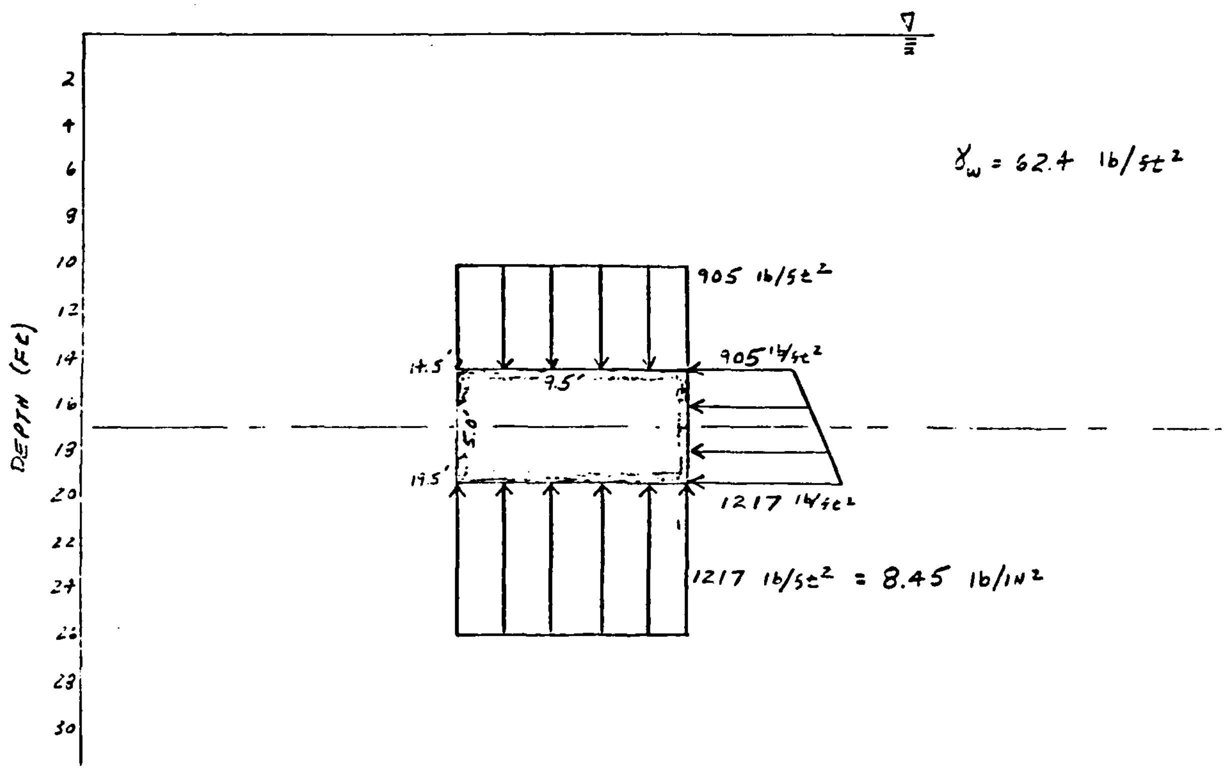
BUOY SIZE	STRESSES ON BOTTOM PLATE AT 17' KSI	FACTOR OF SAFETY AT 17'	DEPTH TO YIELD STRESS OF STEEL (ft)	
9.5' x 5.0'	18	2.0	39	*
10.5' x 6.6'	27	1.3	26	
10.5' x 7.5'	27	1.3	26	

* Buoys used at Seneca

GPO 885-033

CHESAPEAKE DIVISION Naval Facilities Engineering Command NDW DISCIPLINE	PROJECT: ____ Station: ____
Calcs made by: VITALE date: 24 MAY 83 Calcs ck'd by: Wms date: 25 May 83	E S R: ____ Contract: ____ Calculations for: ____

PROBLEM: AT SPECIFIED PULL OF 30,000 POUNDS, THE BUOY WILL SINK APPROXIMATELY 17 FEET. WILL IT IMPLODE?

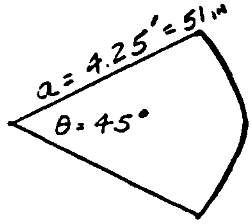


ASSUMPTIONS:

1. SINCE PRESSURE IS EXTERNAL, PUSHING IN ON MOORING, IT IS ASSUMED THAT THE CURVED CYLINDER WILL BE MUCH STRONGER THAN THE BOTTOM. THEREFORE THE WORST CASE WILL BE THE STRENGTH OF THE BOTTOM.
2. THE BOTTOM HAS A SERIES OF SPOKES WHICH BREAKS IT UP INTO 8 CIRCULAR SECTORS (PIE SLICES). THE ANALYSIS WILL BE DONE ON A CIRCULAR SECTOR.

CHESAPEAKE DIVISION	PROJECT:
Naval Facilities Engineering Command NDW	Station:
DISCIPLINE	E S R: Contract:
Calcs made by: VITALE date: 24 MAY 83	Calculations for:
Calcs ck'd by: ?/MC date: 25 May 83	

CIRCULAR SECTOR:



$t = \frac{3}{8}'' = 0.375$ in $\quad w = 8.45$ lb/in²

$E = 29{,}000{,}000$ (lb/in²)

FROM ROARK (1943), TABLE X, NO 67:

$$\text{MAX } S_r = \beta \frac{wa^2}{t^2} \qquad \text{MAX } S_t = \beta_1 \frac{wa^2}{t^2} \qquad \text{MAX } y = \frac{\alpha w a^4}{E t^3}$$

S_r = RADIAL UNIT STRESS ON PLATE SURFACE (lb/in²)

S_t = TANGENTIAL UNIT STRESS ON PLATE SURFACE (lb/in²)

w = UNIT APPLIED LOAD (lb/in²)

t = THICKNESS OF PLATE (IN)

y = VERTICAL DEFLECTION (IN)

E = MODULUS OF ELASTICITY

$\beta = 0.102 \qquad \beta_1 = 0.114 \qquad \alpha = 0.0054$

$$\text{MAX } S_r = \beta wa^2/t^2 = \frac{(0.102)(8.45 \tfrac{lb}{in^2})(51 \text{ in})^2}{(0.375 \text{ in})^2}$$

$$\boxed{S_{r_{MAX}} = 15{,}942 \text{ lb/in}^2}$$

$$\text{MAX } S_t = \beta_1 wa^2/t^2 = \frac{(0.114)(8.45 \tfrac{lb}{in})(51 \text{ in})^2}{(0.375 \text{ in})^2}$$

$$\boxed{S_{t_{MAX}} = 17{,}817 \text{ lb/in}^2}$$

$$\text{MAX } y = \alpha wa^4/Et^3$$

$$= \frac{(0.0054)(8.45 \text{ lb/in}^2)(51 \text{ in})^4}{(29 \times 10^6 \text{ lb/in}^2)(0.375 \text{ in})^3} = \boxed{0.202 \text{ in} = Y_{max}}$$

GPO 885-653

CHESAPEAKE DIVISION	PROJECT:
Naval Facilities Engineering Command NDW	Station:
DISCIPLINE	E S R: Contract:
Calcs made by: VITALE date: 25 MAY 83	Calculations for:
Calcs ck'd by: WMC date: 25 May 83	

THE CALCULATED DEFLECTION IS OVER HALF THE PLATE THICKNESS. ROARK (1943), PAGE 213, NOTES THAT IN THIS CASE:

"... THE PLATE IS STIFFER THAN INDICATED BY THE ORDINARY THEORY, AND THE LOAD-DEFLECTION AND LOAD STRESS RELATIONS ARE NON-LINEAR. STRESSES FOR A GIVEN LOAD ARE LESS, AND STRESSES FOR A GIVEN DEFLECTION ARE GENERALLY GREATER, THAN THE ORDINARY THEORY INDICATES."

THE IMPORTANT PHRASE ABOVE IS THAT STRESSES FOR A GIVEN LOAD ARE LESS. THEREFORE THE STRESSES CALCULATED ON THE PREVIOUS PAGE ARE ACTUALLY CONSERVATIVE.

THE CALCULATED STRESSES CAN NOW BE COMPARED TO THE YIELD STRESS OF THE A36 STEEL (PAGE 1-5 OF STEEL MANUAL). ROUNDING UP THE CALCULATED STRESSES:

$$S_{r_{MAX}} = 16 \text{ KIPS} \qquad S_{t_{MAX}} = 18 \text{ KIPS}$$

THE YIELD STRESS IS $F_y = 36$ KIPS. THE CIRCULAR SECTOR SHOULD NOT FAIL AND HAS A FACTOR OF SAFETY OF:

$$FS = \frac{36}{18} = 2$$

THE DEPTH AT WHICH THE YIELD STRESS, 36 KIPS, WILL BE REACHED IS:

$$w = \frac{S_r t^2}{\beta a^2} = \frac{(36{,}000 \frac{lb}{in^2})(0.375 \text{ in})^2}{(0.114)(51 \text{ in})^2} = 17.07 \text{ lb/in}^2$$

$$d_{ft} = \frac{(17.07 \frac{lb}{in^2})(144 \frac{in^2}{ft^2})}{62.4 \,(lb/ft^3)} = 39 \text{ FEET}$$

GPO 885-053

CHESAPEAKE DIVISION	PROJECT:
Naval Facilities Engineering Command NDW	Station:
DISCIPLINE	E S R: Contract:
Calcs made by: VITALE date: 25 MAY 83	Calculations for:
Calcs ck'd by: MMS date: 26 May 83	

$S_{t_{max}}$ IS THE LARGER STRESS. ITS VALUE FOR THE OTHER TWO BUOYS IS THE SAME FOR BOTH BUOYS SINCE THEY HAVE THE SAME DIAMETER, 10.5'.

$$S_{t_{max}} = \frac{\beta_1 w a^2}{t^2} = \frac{(0.114)(8.45 \frac{lb}{in^2})(63 \text{ in})^2}{(0.375 \text{ in})^2} = 27{,}188 \text{ lb/in}^2$$

ALLOWABLE DEPTH: YIELD STRESS = 36,000 lb/in²

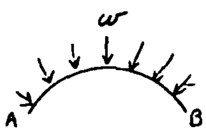
$$d \text{ ft} = \frac{S_t t^2}{\beta_1 a^2}\left(\frac{144 \frac{in^2}{ft^2}}{\gamma}\right) = \frac{(36{,}000 \frac{lb}{in^2})(0.375 \text{ in})^2 (144 \frac{in^2}{ft^2})}{(0.114)(63 \text{ in})^2 (62.4 \text{ lb/ft}^3)} = 25.82 \text{ ft}$$

GPO 885-853

CHESAPEAKE DIVISION	PROJECT:
Naval Facilities Engineering Command NDW	Station:
DISCIPLINE	E S R: Contract:
Calcs made by: VITALE date: 25 MAY 83	Calculations for:
Calcs ck'd by: Wms date: 26 May 83	

FOR THE CURVED SIDE PANELS:

FROM ROARK (1943), PAGE 306, THE UNIT EXTERNAL PRESSURE AT WHICH BUCKLING OCCURS FOR A $\boxed{\text{CURVED PANEL}}$ IS GIVEN.



$$w' = \frac{E\, t^3 \left(\pi^2/\alpha^2 - 1\right)}{12\, r^3 \left(1 - \nu^2\right)}$$

r = RADIUS OF CURVATION = 51 IN

t = THICKNESS = 0.375 IN

α = CENTRAL ANGLE

$$= \frac{\text{ARC } AB}{2r} = \frac{r(\pi/4)}{2r} = \pi/8$$

ν = POISSON'S RATIO = 0.3

$$w' = \frac{\left(29 \times 10^6 \ \tfrac{lb}{IN^2}\right)\left(0.375 \ IN\right)^3 \left(\pi^2/(\pi/8)^2 - 1\right)}{12\, (51 \ IN)^3 \left(1 - 0.3^2\right)}$$

$$= \frac{\left(29 \times 10^6 \ \tfrac{lb}{IN^2}\right)\left(0.375 \ IN\right)^3 \overset{63}{\cancel{(64-1)}}}{(12)(51 \ IN)^3 \underset{0.91}{(1 - 0.09)}} = 66.5 \ lb/IN^2$$

THIS SHOWS THAT THE CIRCULAR PANEL WILL BE ABLE TO WITHSTAND THE 8.45 lb/IN² OF PRESSURE AT 19.5'.

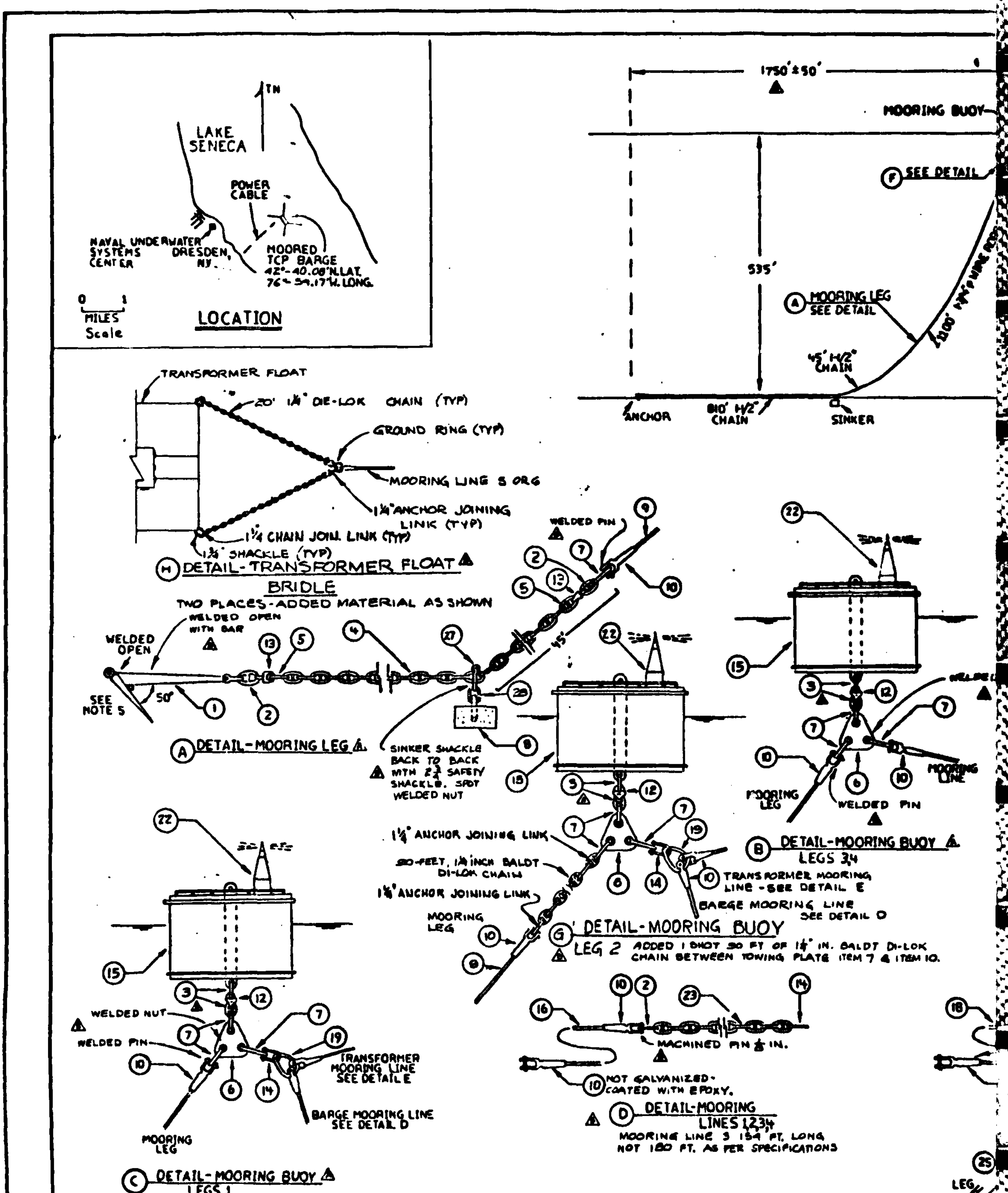
FROM ROARK (1943), PAGE 306, THE UNIT EXTERNAL PRESSURE AT WHICH BUCKLING OCCURS FOR A $\boxed{\text{THIN TUBE}}$ UNDER UNIFORM LATERAL EXTERNAL PRESSURE IS GIVEN BY:

$$w' = 0.807 \frac{E\, t^2}{l\, r} \sqrt[4]{\left(\frac{1}{1-\nu^2}\right)^3 \frac{t^2}{r^2}} = \frac{0.807 \left(29 \times 10^6 \ \tfrac{lb}{IN^2}\right)\left(0.375 \ IN\right)^2}{(60 \ IN)(51 \ IN)} \underbrace{\left[\left(\frac{1}{\underset{0.91}{1-0.09}}\right)^3 \frac{(0.375 \ IN)^2}{(51 \ IN)^2}\right]^{1/4}}_{0.092}$$

l = TUBE LENGTH

$$w' = 98.98 \ lb/IN^2$$

THEREFORE, THE MOORING, IF CONSIDERED TO BE A TUBE, CAN EASILY WITHSTAND THE 8.45 lb/IN² OF PRESSURE AT 19.5'.



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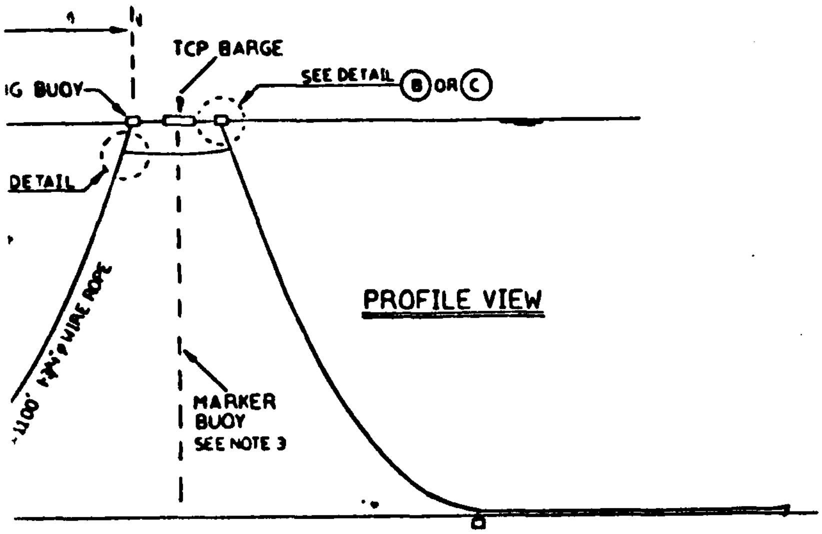
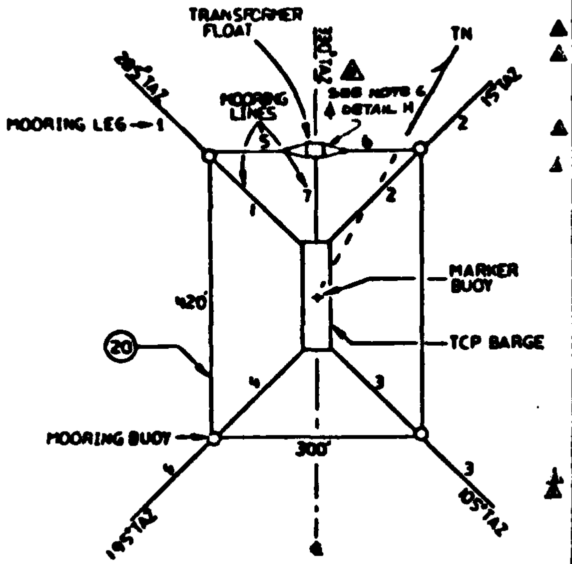


PROFILE VIEW

SYMBOL	DESCRIPTION	DATE	APPROVED
▲	PC 1 was DE LUT, QTY CHGD - PC 2 was 30, PC 3 was deleted from Detail A, PC 3 was added to Details B & C, PC 5 was 40, PC 7 was 20, PC 20 was 2500; PC 19 was 1-7/8"; NEW PC 27; DIM CHG PROFILE - was 1650'; revised Note 5.	5/10/[illegible]	[illegible]
▲	ADDED DETAIL G & H, ADDED BRIDLE CONNECTION TO TRANSFORMER FLOAT IN PLAN VIEW. LEG 2 REMOVED FROM DETAIL C. ADDED NOTES TO DETAIL A. ADDED NOTES TO DETAIL B. ADDED NOTES TO DETAIL C. ADDED NOTES TO DETAIL D. ADDED NOTE TO DETAIL E. ADDED NOTE TO DETAIL F. ADDED NOTE G. ADDED PIECE NO. 28	8/17/81	[illegible]

FINAL BARGE HEADING 328.5° T AZ



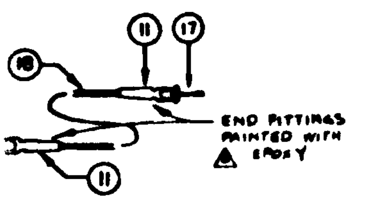
PLAN VIEW

- WELDED NUT

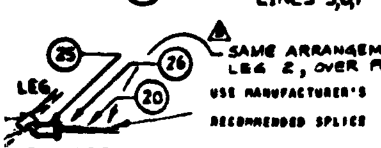
7

MOORING
LINE

PIECE NO.	PART OR IDENT. NO.	QTY. REQD.	DESCRIPTION	SPEC.	MATERIAL
1		4	[illegible] ANCHOR, 3000#, OR EQUAL		STEEL
2		[illegible]	ANCHOR JOINING LINK, 1-1/2"		STEEL
3	No. 6	[illegible]	DETACHABLE ANCHOR CONNECTING LINK, BALDT OR EQUAL		STEEL
4		6	ABS STUD LINK CHAIN, 1-1/2", GRADE 3, 9-1/2 90' SHOTS, BALDT OR EQUAL		STEEL
5		[illegible]	JOINING CHAIN LINKS, 1-1/2", BALDT OR EQUAL		STEEL
6	No. 1	[illegible]	TOWING PLATES [illegible] OR EQUAL		STEEL
7	G2130	16	ANCHOR SHACKLES, BOLT TYPE, 1-3/4", CROSBY OR EQUAL		STEEL
8		6	CONCRETE SINKERS, [illegible]#, 8' x 8' x 3.25' with 2" DIA. STEEL HAIRPIN (MIL-C-[illegible])	[illegible] P-[illegible]	CONCRETE STEEL
9		6	6x37 WIRE ROPE, GALVANIZED, 1-3/4", 1100' LENGTHS		GALVANIZED STEEL
10	S501	16	OPEN SWAGE WIRE ROPE FITTINGS, 1-3/4" ROPE, CROSBY OR EQUAL		STEEL
11	S501	6	OPEN SWAGE WIRE ROPE FITTINGS, 1-1/4" ROPE, CROSBY OR EQUAL		STEEL
12		6	SWIVELS, 3", VICINAY INTERNAT'L CO. OR EQUAL		STEEL
13		[illegible]	SWIVELS, 1-1/2", VICINAY INTERNATIONAL CO. OR EQUAL		STEEL
14	G2130	6	SHACKLES, 1-3/4", CROSBY OR EQUAL		STEEL
15	NAVFAC DWG NO. [illegible]	4	STEEL MOORING BUOYS, 9.5' O.D. x 8.0' HEIGHT	MIL-B-[illegible]	STEEL
16		6	6x37 IWRC WIRE ROPE, GALVANIZED 1-3/4", 100' LENGTHS, UNITED STATES STEEL OR EQUAL		GALVANIZED STEEL
17	G213	3	ROUND PIN ANCHOR SHACKLES, 1-1/4", CROSBY OR EQUAL		STEEL
18		3	6x37 IWRC WIRE ROPE, GALVANIZED 1-1/4", 135' LENGTHS, UNITED STATES STEEL OR EQUAL		GALVANIZED STEEL
19		3	PEAR LINK, 1-1/2", BALDT OR EQUAL		STEEL
20		[illegible]	NYLON LINE, 1" [illegible]		NYLON
21	[illegible]	[illegible]	NAVIGATION AID LIGHTS		[illegible]
22		6	ABS STUD LINK CHAIN, 1-1/2", GRADE 3, 10' LENGTHS, BALDT OR EQUAL		STEEL
24	[illegible]	[illegible]	WIRE ROPE CLIP, 1-3/4" WIRE ROPE, CROSBY OR EQUAL		STEEL
25		6	ROUND PIN ANCHOR SHACKLES, 1-1/2", BALDT OR EQUAL		STEEL
26		[illegible]	THIMBLES FOR 1" DIA. ROPE		STEEL
27		6	ANCHOR SHACKLE, 1-1/2", BALDT OR EQUAL		STEEL
28		4	SHACKLE 1½" BALDT		STEEL



E DETAIL MOORING LINES 5,6,7



F DETAIL - TEMPORARY LINE
SEE NOTE 4

NOT TO SCALE
UNLESS INDICATED

NOTES

1. TCP BARGE (33 x 150') AND TRANSFORMER FLOAT (15 x 19') TO BE PROVIDED AND MOORED BY THE GOVERNMENT. THE CENTER LINE OF THE TCP BARGE HAS AN AZIMUTH OF 330°.
2. MOORING LINES 1,2,3,4,5 and 6 WILL BE ATTACHED AS SHOWN TO THE MOORING BUOYS. MOORING ENDS OF THE LINES WILL BE TEMPORARILY ATTACHED TO THE TOPS OF THE MOORING BUOYS. LINE 7 WILL BE PROVIDED TO THE GOVERNMENT.
3. ALL MEASUREMENTS MADE BY THE CONTRACTOR WILL BE IN REFERENCE TO THE GOVERNMENT INSTALLED MARKER BUOY.
4. TEMPORARY LINES (Pc No 20) WILL BE ATTACHED TO THE MOORING LEG AT LEAST 20' BELOW THE WATER SURFACE.
5. WELD ANCHORS OPEN AT A 50° ANGLE, EXTEND STABILIZER BARS TO 36 INCHES.
6. FIT BRIDLE TO PADEYES EACH END OF TRANSFORMER FLOAT

DESIGNED BY WHS	DEPARTMENT OF THE NAVY NAVAL FACILITIES ENGINEERING COMMAND
DRAWN BY WHS	CHESAPEAKE DIVISION
CHECKED BY [illegible]	WASHINGTON, D.C.
APPROVED [illegible] DATE 8-10-82	NUSC LAKE SENECA, N.Y. TRANSDUCER CALIBRATION PLATFORM (TCP) 4 POINT MOORING SITE, PLAN & DETAILS
[illegible] DATE 10-82	SIZE F · CODE IDENT NO. 80091 · NAVFAC DRAWING NO. 3026161 · REV B
SCALE	SPEC. · SHEET 1 OF 1

292